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Shin

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(54) **SYNCHRONIZATION CIRCUIT**

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H03L 7/06 (2006.01)

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USPC **327/158; 327/149**

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(58) **Field of Classification Search**
USPC 327/147, 158
See application file for complete search history.

(57) **ABSTRACT**

A synchronization circuit includes a first delay unit configured to delay an input signal by a delay time corresponding to first initial delay information and generate a pre-delayed signal; a second delay unit configured to delay the pre-delayed signal by a delay time corresponding to second initial delay information and generate a delayed signal; and an initial delay monitoring circuit configured to generate the first initial delay information and the second initial delay information in response to internal delayed signals of the first delay unit and the input signal.

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23 Claims, 8 Drawing Sheets

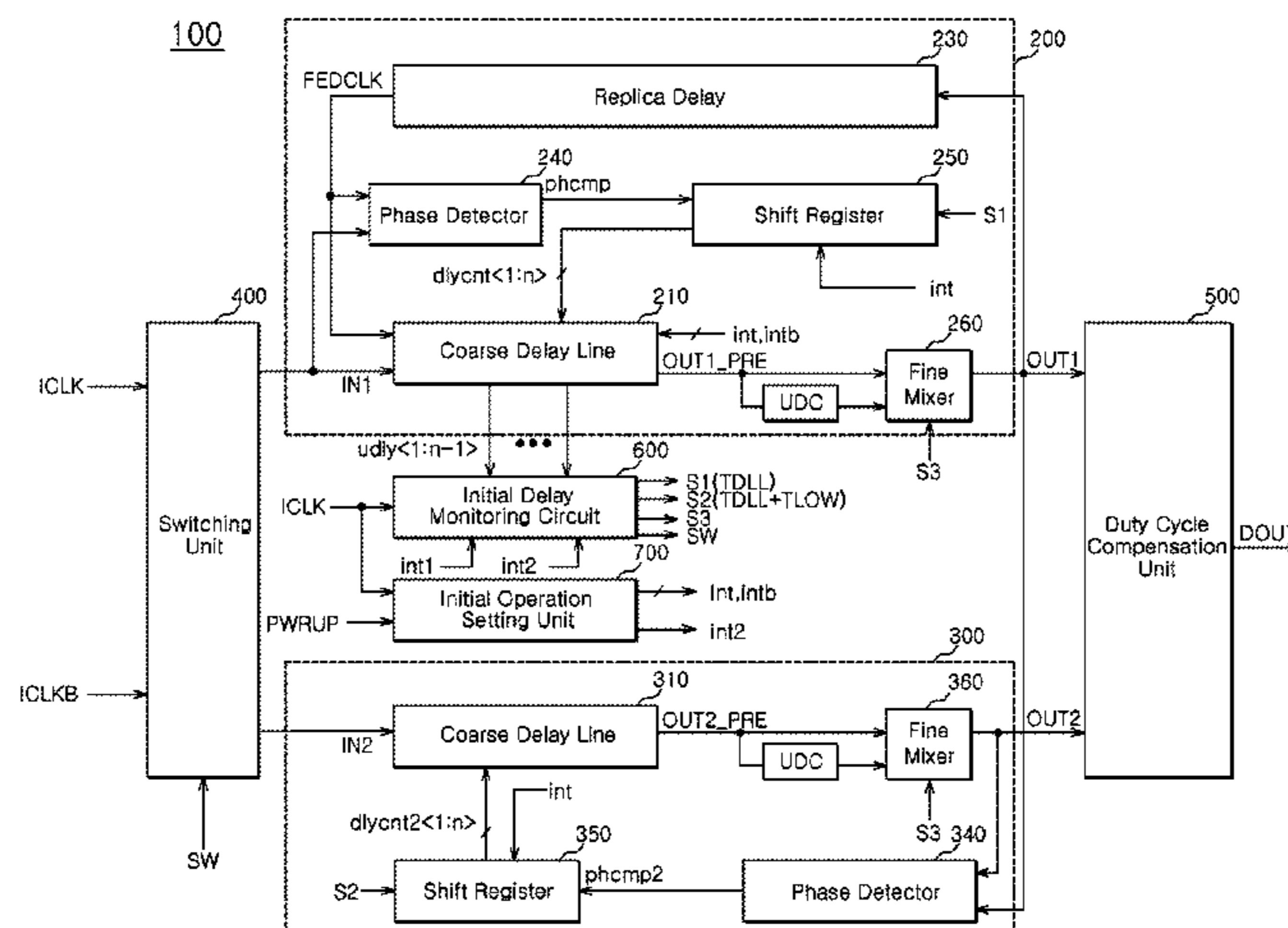


FIG. 1

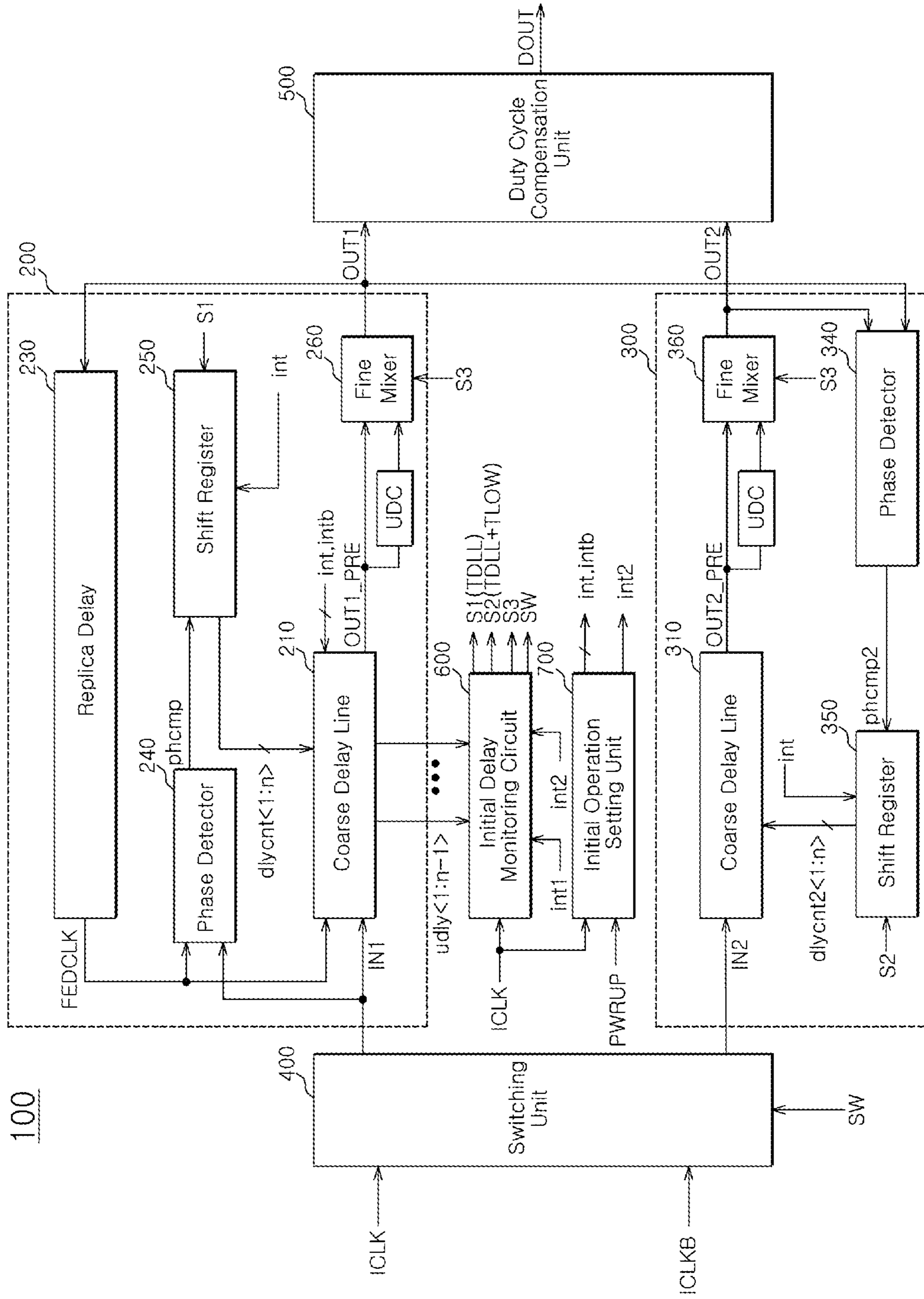


FIG.2A

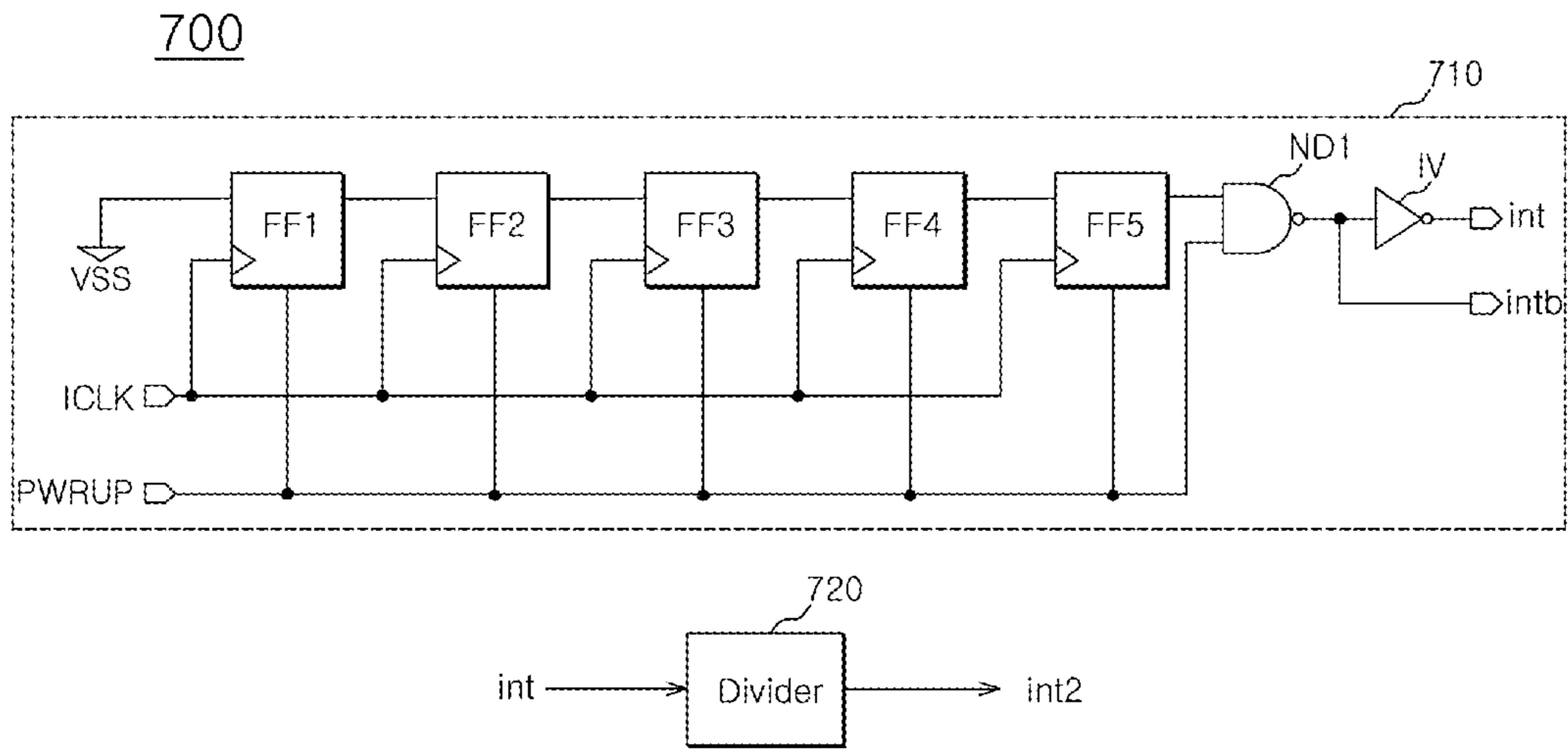


FIG.2B

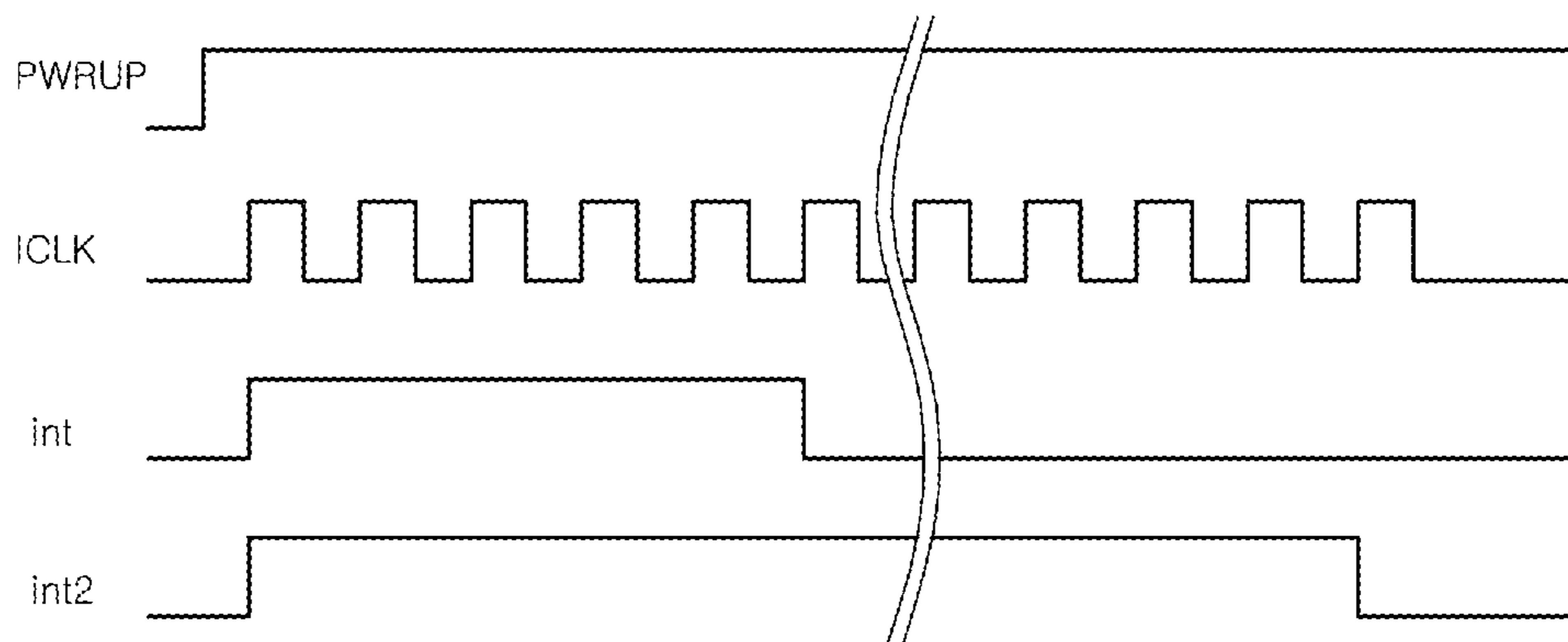


FIG. 3

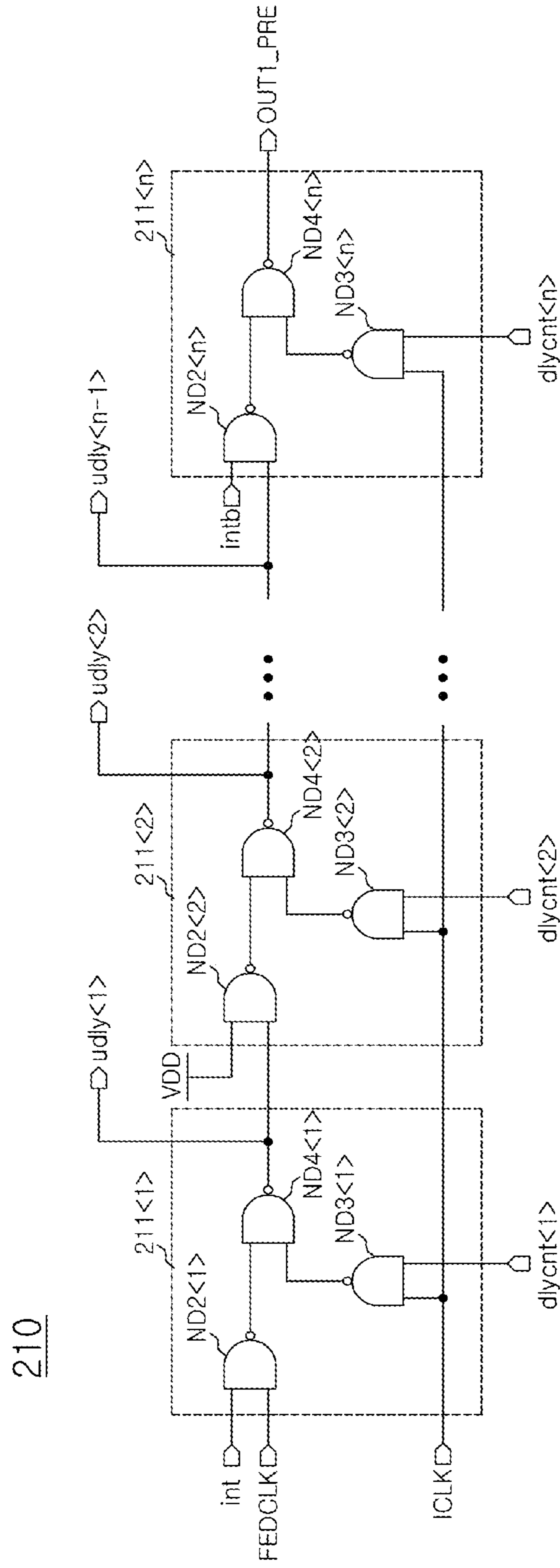


FIG. 4

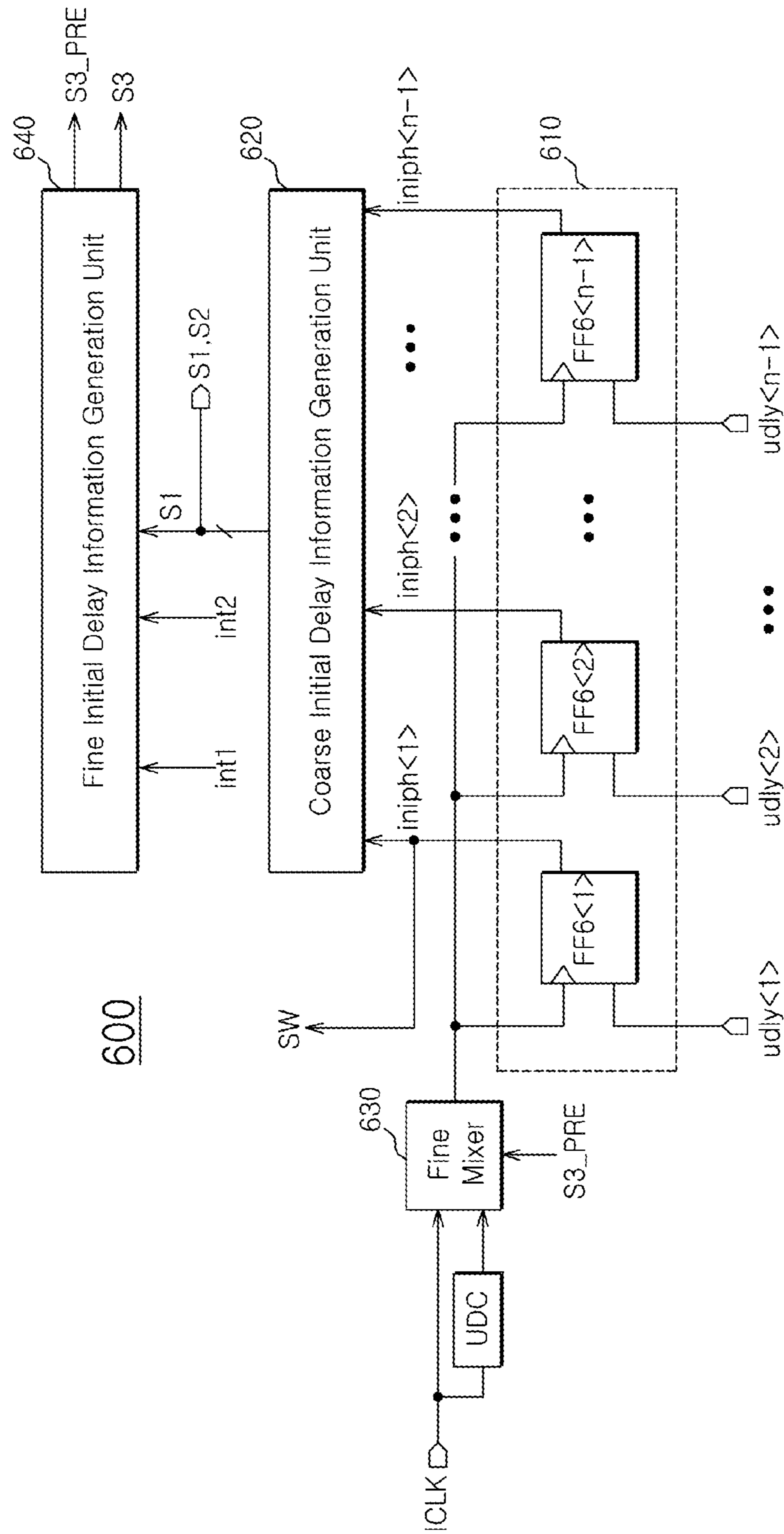


FIG.5

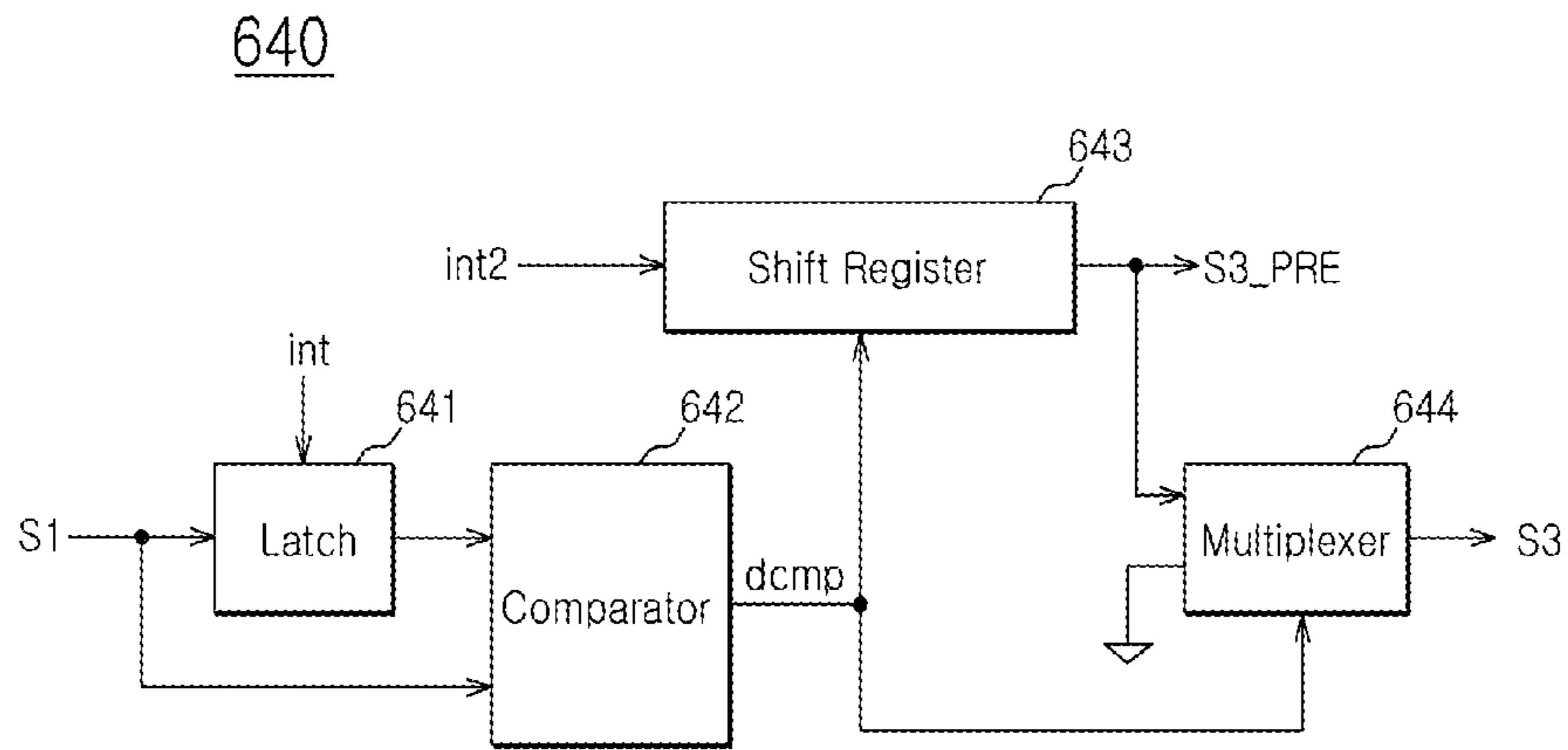


FIG.6

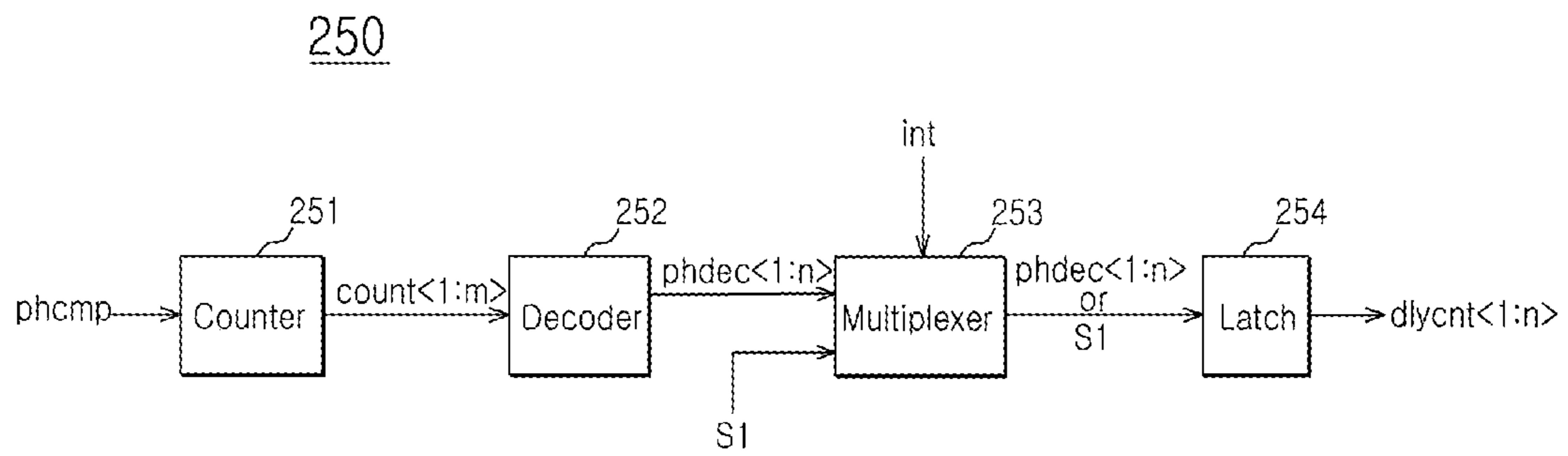
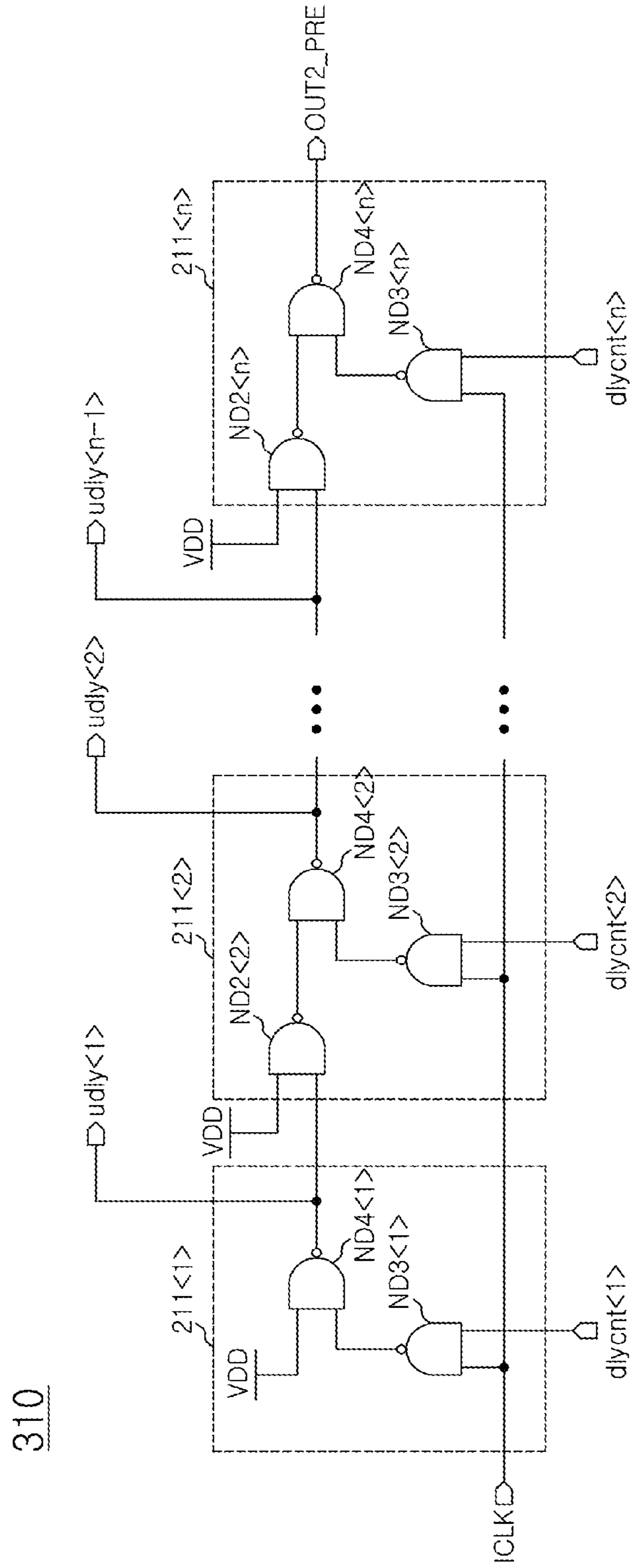


FIG. 7



310

FIG.8

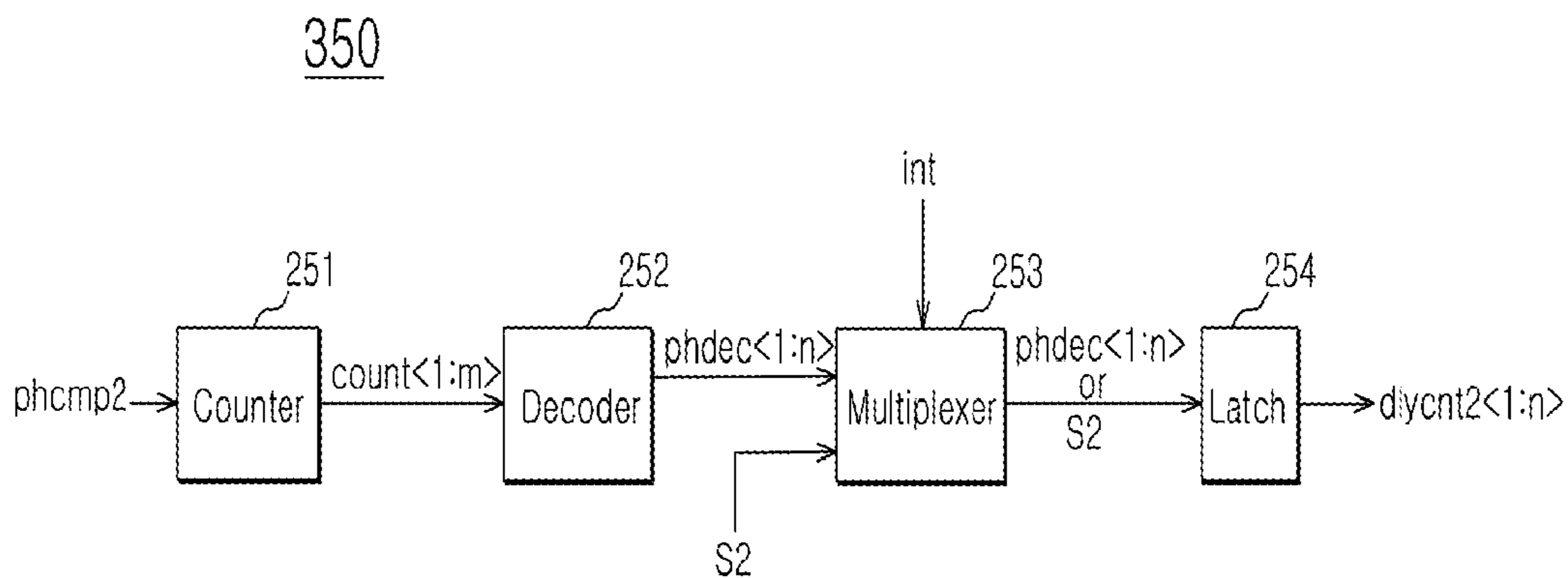


FIG.9A

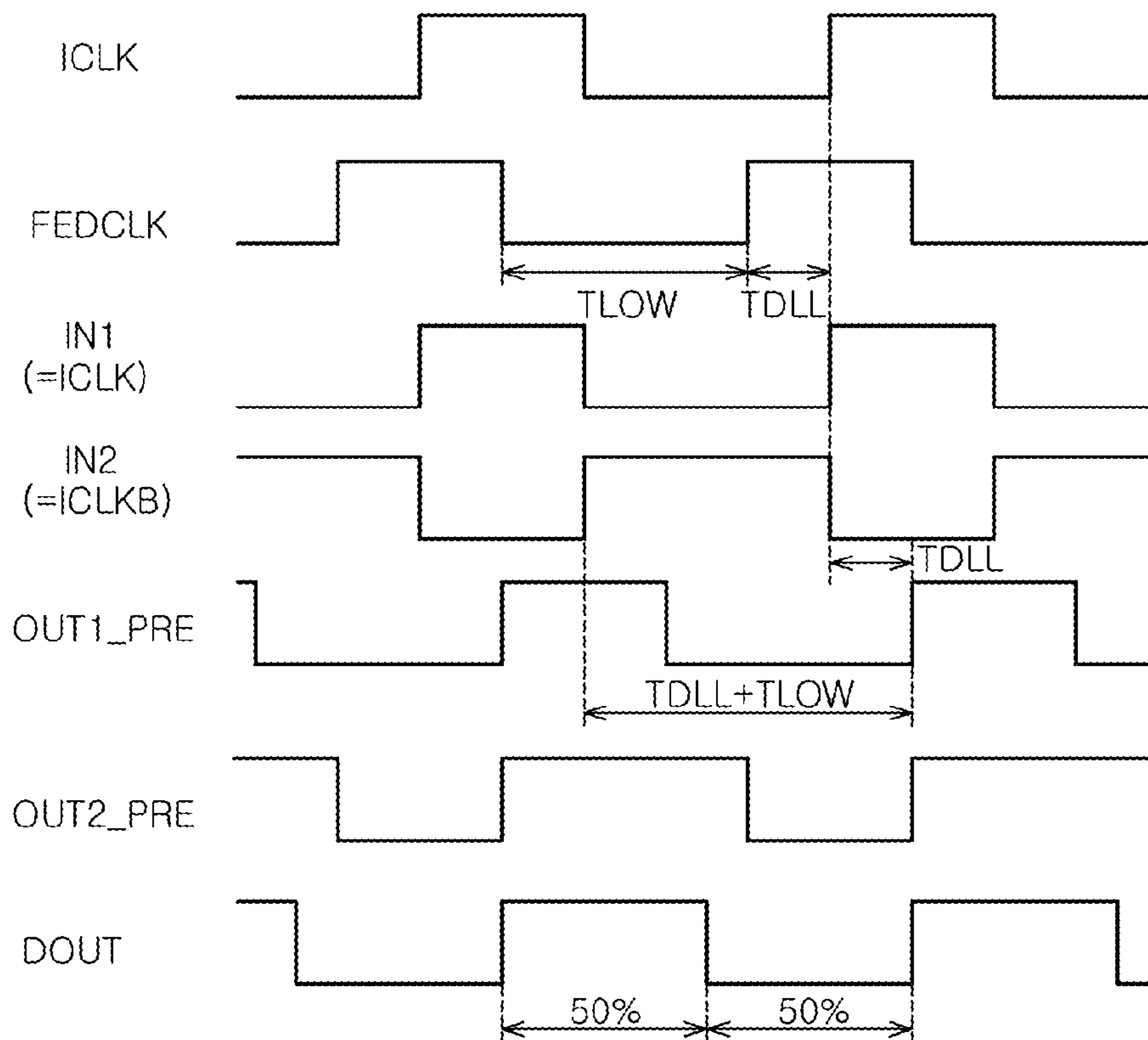
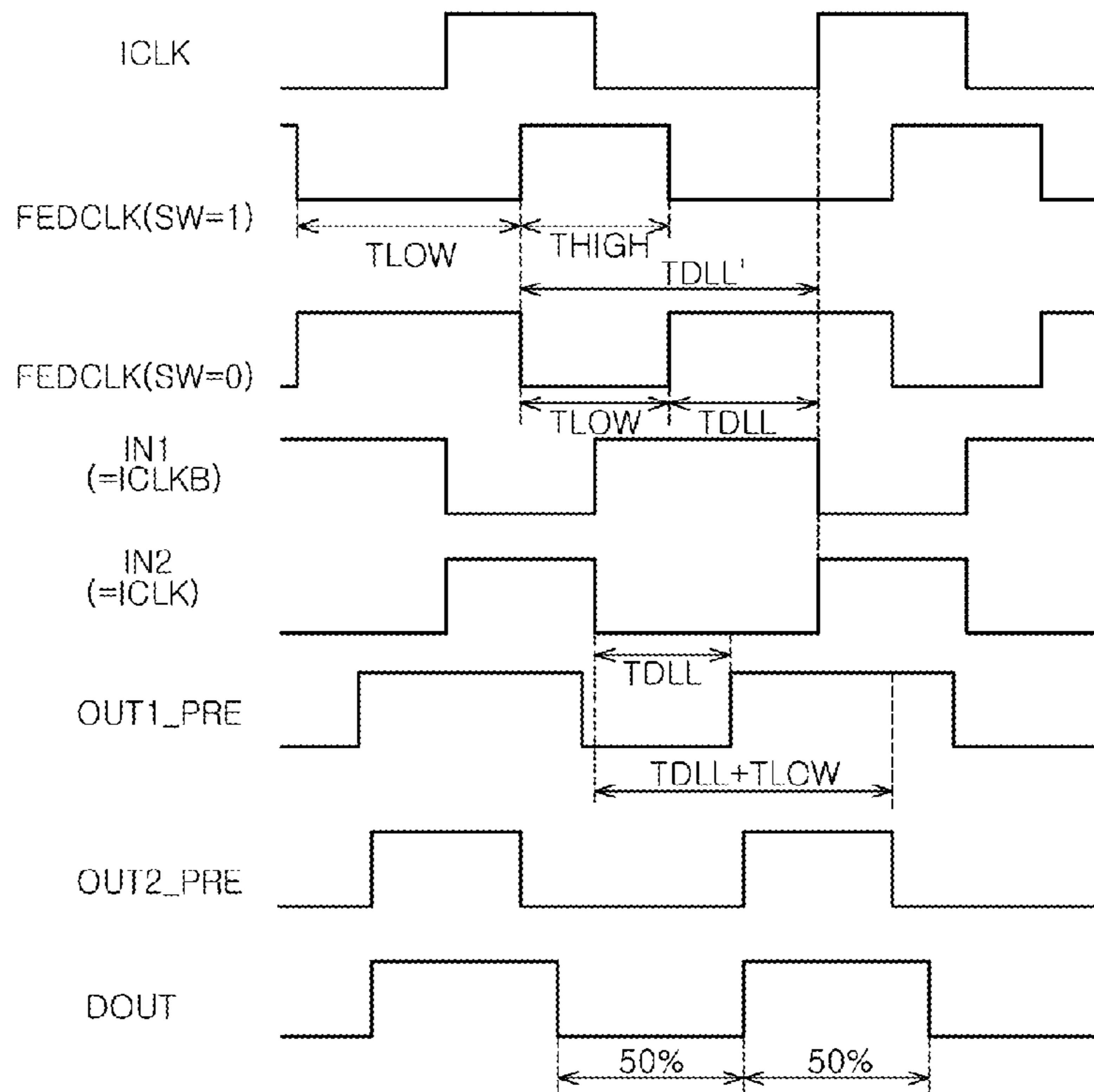


FIG.9B



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SYNCHRONIZATION CIRCUIT

CROSS-REFERENCES TO RELATED APPLICATION

The present application claims priority under 35 U.S.C. §119(a) to Korean application number 10-2011-0009270, filed on Jan. 31, 2011, in the Korean Intellectual Property Office, which is incorporated herein by reference in its entirety as set forth in full.

BACKGROUND

1. Technical Field

The present invention relates generally to a semiconductor circuit, and more particularly, to a synchronization circuit.

2. Related Art

A semiconductor circuit may include a synchronization circuit for delay locking or duty cycle compensation, such as a DLL (delay locked loop) or a DCC (duty cycle corrector).

The delay locked loop may be used to change the phase of a clock signal, usually to improve, for example, the clock rise-to-data output valid timing characteristics of integrated circuits such as DRAM devices.

The duty cycle corrector may be used to compensate for a skew in a duty cycle of a clock signal.

In order to accommodate the trend of a semiconductor integrated circuit toward high speed operation, it is preferred that a delay locking operation and a duty cycle correcting operation be performed as quick and precise as possible.

SUMMARY

A synchronization circuit which can not only shorten a time required for a delay locking operation but also shorten a time required for a duty cycle compensating operation is described herein.

In an embodiment of the present invention, a synchronization circuit includes: a first delay unit configured to delay an input signal by a delay time corresponding to first initial delay information and generate a pre-delayed signal; a second delay unit configured to delay the pre-delayed signal by a delay time corresponding to second initial delay information and generate a delayed signal; and an initial delay monitoring circuit configured to generate the first initial delay information and the second initial delay information in response to internal delayed signals of the first delay unit and the input signal.

In an embodiment of the present invention, a synchronization circuit includes: a first loop circuit configured to change a delay time of a first input signal in response to first coarse initial delay information and fine initial delay information, and generate a first delayed signal; a second loop circuit configured to change a delay time of a second input signal by a preset initial delay time in response to second coarse initial delay information and the fine initial delay information, and generate a second delayed signal; a duty cycle compensation unit configured to compensate for a duty cycle of the first delayed signal using the second delayed signal; and an initial delay monitoring circuit configured to generate the first coarse initial delay information, the second coarse initial delay information and the fine initial delay information in response to internal delayed signals of the first loop circuit and the first input signal.

BRIEF DESCRIPTION OF THE DRAWINGS

Features, aspects, and embodiments are described in conjunction with the attached drawings, in which:

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FIG. 1 is a block diagram illustrating a synchronization circuit **100** in accordance with an embodiment of the present invention;

FIG. 2a is a circuit diagram of an initial operation setting unit **700** of FIG. 1;

FIG. 2b is a timing diagram of the initial operation setting unit **700** of FIG. 2a;

FIG. 3 is a circuit diagram of the coarse delay line **210** of FIG. 1;

FIG. 4 is a block diagram showing the internal configuration of an initial delay monitoring circuit **600** of FIG. 1;

FIG. 5 is a block diagram showing the internal configuration of a fine initial delay information generation unit **640** of FIG. 4;

FIG. 6 is a block diagram showing the internal configuration of a shift register **250** of FIG. 1;

FIG. 7 is a circuit diagram of a coarse delay line **310** of FIG. 1;

FIG. 8 is a block diagram showing the internal configuration of a shift register **350** of FIG. 1; and

FIGS. 9a and 9b are timing diagrams illustrating operations of the synchronization circuit in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION

Hereinafter, a synchronization circuit according to the present invention will be described below with reference to the accompanying drawings through exemplary embodiments.

Referring to FIG. 1, a synchronization circuit **100** in accordance with an embodiment of the present invention includes a first loop circuit **200**, a second loop circuit **300**, a switching unit **400**, a duty cycle compensation unit **500**, an initial delay monitoring circuit **600**, and an initial operation setting unit **700**.

A delay locked loop circuit, that is, the first loop circuit **200** is configured to set an initial delay time using first coarse initial delay information **S1** and fine initial delay information **S3**, adjust the delay time of a first input signal **IN1**, and generate a first delayed signal **OUT1**.

The first loop circuit **200** includes a first delay unit **210**, a replica delay **230**, a phase detector **240**, a shift register **250**, a unit delay **UDC**, and a second delay unit **260**.

The second delay unit **260** is configured to have a unit delay time shorter than that of the first delay unit **210**. The first delay unit **210** may be configured as a coarse delay line **210**, and the second delay unit **260** may be configured as a fine mixer **260**.

As will be described later, a unit delay time means the delay time of each of a plurality of unit delay sections which constitute each of the first delay unit **210** and the second delay unit **260**.

The coarse delay line **210** is configured to delay the first input signal **IN1** or a feedback signal **FEDCLK** in response to initial operation period signals **int** and **intb** and first delay control signals **dlycnt<1:n>**, and generate a plurality of unit delayed signals **udly<1:n-1>** and a first pre-delayed signal **OUT1_PRE**.

The shift register **250** is configured to generate the first delay control signals **dlycnt<1:n>** in response to the initial operation period signal **int**, a phase comparison signal **phcmp** and the first coarse initial delay information **S1**.

The unit delay **UDC** is configured to delay by a unit delay time and output a delayed first pre-delayed signal **OUT1_PRE**. The unit delay time of the unit delay **UDC** is set to be the same as the unit delay time of the coarse delay line **210**.

The fine mixer **260** is configured to mix the first pre-delayed signal OUT1_PRE and the output signal of the unit delay UDC, i.e. the delayed first pre-delayed signal OUT1_PRE, at a preset mixing ratio in response to the fine initial delay information S3, and generate the first delayed signal OUT1.

The fine mixer **260** bypasses the first pre-delayed signal OUT1_PRE, according to an example, in the case where all bits of the fine initial delay information S3 have low logic levels.

The replica delay **230** is configured to have a preset delay time, that is, a delay time that is acquired by modeling delay times by the delay elements existing on a path through which the first delayed signal OUT1 proceeds to a data output buffer.

The phase detector **240** is configured to compare the phases of the first input signal IN1 and the feedback signal FEDCLK, and generate the phase comparison signal phcmp.

The phase detector **240** may be realized using a flip-flop circuit of an edge trigger type.

A duty cycle compensation loop circuit, that is, the second loop circuit **300** is configured to set an initial delay time using a second coarse initial delay information S2 and the fine initial delay information S3, adjust the delay time of a second input signal IN2, and generate a second delayed signal OUT2 for compensating for the duty cycle of the first delayed signal OUT1.

The second loop circuit **300** includes a coarse delay line **310**, a phase detector **340**, a shift register **350**, a unit delay UDC and a fine mixer **360**.

The coarse delay line **310** is configured to delay the second input signal IN2 in response to a second delay control signals dlycnt2<1:n> and generate a second pre-delayed signal OUT2_PRE.

The coarse delay line **310** is configured to have the same unit delay time as the coarse delay line **210**.

The unit delay UDC is configured to delay by a unit delay time and output a delayed second pre-delayed signal OUT2_PRE. The unit delay time of the unit delay UDC is set to be the same as the unit delay time of the coarse delay line **310**.

The fine mixer **360** is configured to mix the second pre-delayed signal OUT2_PRE and the output signal of the unit delay UDC at a preset mixing ratio in response to the fine initial delay information S3, and generate the second delayed signal OUT2.

The fine mixer **360** bypasses the second pre-delayed signal OUT2_PRE, according to an example, in the case where all bits of the fine initial delay information S3 are logic low.

The phase detector **340** is configured to compare the phases of the first delayed signal OUT1 and the second delayed signal OUT2 and generate a phase comparison signal phcmp2.

The shift register **350** is configured to generate the second delay control signals dlycnt2<1:n> in response to the initial operation period signal int, the phase comparison signal phcmp2 and the second coarse initial delay information S2.

The switching unit **400** is configured to output a clock signal ICLK or a clock bar signal ICLKB as the first input signal IN1 or the second input signal IN2 in response to a switching control signal SW.

The duty cycle compensation unit **500** is configured to compensate for the duty cycle of the first delayed signal OUT1 using the second delayed signal OUT2 and generate a delay-locked and duty cycle-compensated output signal DOUT.

The duty cycle compensation unit **500** may be configured by a mixer which mixes the first delayed signal OUT1 and the second delayed signal OUT2 at the mixing ratio of 1:1.

The initial delay monitoring circuit **600** is configured to generate the switching control signal SW, the coarse initial delay information and the fine initial delay information S3 in response to the internally delayed signals of the first loop circuit **200**, that is, the plurality of unit delayed signals udly<1:n-1>, the clock signal ICLK and initial operation period signals int, intb and int2.

Here, the coarse initial delay information includes the first coarse initial delay information S1 and the second coarse initial delay information S2.

The initial operation setting unit **700** is configured to generate the initial operation period signals int, intb and int2 in response to the clock signal ICLK and an operation start signal, for example, a power-up signal PWRUP.

A semiconductor integrated circuit starts to operate when the power-up signal PWRUP is activated. Therefore, according to an exemplary embodiment of the present invention, the power-up signal PWRUP is used as an operation start signal for instructing the synchronization circuit **100** to start an operation.

Hereafter, an initial delay time setting operation of the synchronization circuit **100** in accordance with an embodiment of the present invention will be described with reference to FIG. 1.

When the initial operation period signal int is activated, the coarse delay line **210** receives and delays the feedback signal FEDCLK. The first delay control signals dlycnt<1:n> which are outputted from the shift register **250** are set initially to a certain logic value.

The certain logic value is a logic value which allows the coarse delay line **210** to generate the unit delayed signals udly<1:n-1> of n-1 bits using the feedback signal FEDCLK and to generate an nth unit delayed signal, that is, the first pre-delayed signal OUT1_PRE using the clock signal ICLK. The unit delayed signals udly<1:n-1> are transferred to the initial delay monitoring circuit **600**. The initial delay monitoring circuit **600** compares the phase of each of n-1 number of unit delayed signals udly<1:n-1> and the clock signal ICLK, and generates the first coarse initial delay information S1 and the second coarse initial delay information S2 according to the phase information of the clock signal ICLK and the feedback signal FEDCLK. Further, according to an example, the initial delay monitoring circuit **600** generates the fine initial delay information S3 using the first coarse initial delay information S1 during the activation period of the initial operation period signal int2.

When the first coarse initial delay information S1 and the second coarse initial delay information S2 are respectively inputted to the shift registers **250** and **350** in a state in which the initial operation period signal int is activated, the shift registers **250** and **350** output the first coarse initial delay information S1 and the second coarse initial delay information S2 as the first delay control signals dlycnt<1:n> and dlycnt2<1:n>, respectively.

The initial delay times of the coarse delay lines **210** and **310** are set according to the first delay control signals dlycnt<1:n> and dlycnt2<1:n>.

Also, initial mixing ratios of the fine mixers **260** and **360** are set according to the fine initial delay information S3. That is to say, initial delay times are set.

As a result, in a state in which the phase difference between the clock signal ICLK and the feedback signal FEDCLK is minimized initially, operations of the first loop circuit **200** and

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the second loop circuit **300** can be started, and accordingly, a time required for completion of delay locking can be shortened.

Referring to FIG. **2a**, the initial operation setting unit **700** includes a shift section **710** and a divider **720**.

The shift section **710** includes first, second, . . . , and fifth flip-flops **FF1**, **FF2**, . . . , and **FF5**. Also, the shift section **710** includes a NAND gate **ND1** and an inverter **IV**.

The first, second, . . . , and fifth flip-flops **FF1**, **FF2**, . . . , and **FF5** are connected in series, and each of the fifth flip-flops is initialized by the power-up signal **PWRUP** to output signals of a high level. Also, each of the first, second, . . . , and fifth flip-flops **FF1**, **FF2**, . . . , and **FF5** receives and latches the output signal of previous flip-flop in response to the clock signal **ICLK**. The first flip-flop **FF1**, which is arranged at the front end, receives ground power **VSS**. The NAND gate **ND1** receives the output signal of the fifth flip-flop **FF5** and the power-up signal **PWRUP**. The inverter **IV** receives the output signal of the NAND gate **ND1** and outputs the initial operation period signals **int** and **intb**.

If the clock signal **ICLK** toggles after the power-up signal **PWRUP** is activated, and the fifth flip-flop **FF5** outputs a high level signal, the initial operation period signal **int** is activated to a high level. Because the ground power **VSS** is transferred to the NAND gate **ND1**, according to an example, after the clock signal **ICLK** toggles 5 times, the initial operation period signal **int** maintains an activation period for 5 cycles of the clock signal **ICLK**.

The divider **720** is configured to divide the initial operation period signal **int** by a preset division ratio and generate the initial operation period signal **int2**.

The division ratio of the divider **720** may vary in proportion to the bit number of the fine initial delay information **S3**.

The waveforms of the power-up signal **PWRUP**, the clock signal **ICLK** and the initial operation period signals **int** and **int2** are shown in FIG. **2b**.

As will be described later, in an embodiment of the present invention, after the first coarse initial delay information **S1** and the second coarse initial delay information **S2** are generated, the fine initial delay information **S3** is generated.

The initial operation period signal **int** may represent the completion of adjustments of the first coarse initial delay information **S1** and the second coarse initial delay information **S2**, and the initial operation period signal **int2** may represent the completion of adjustment of the fine initial delay information **S3**.

A period through which the initial operation period signal **int** is activated may be determined in such a way as to include a time for the replica delay **230** to generate the feedback signal **FEDCLK** in an initial operation and a time for the initial delay monitoring circuit **600** to generate the first coarse initial delay information **S1** and the second coarse initial delay information **S2**.

The initial operation period signal **intb** is a signal which has a phase opposite to the initial operation period signal **int**.

The initial operation period signal **int2** is activated at the same timing as the initial operation period signal **int**. The activation period of the initial operation period signal **int2** may be determined in such a way as to include a time for the initial delay monitoring circuit **600** to generate the fine initial delay information **S3** using the first coarse initial delay information **S1**.

Accordingly, the activation period of the initial operation period signal **int2** is set to be longer than the initial operation period signal **int**.

While, according to an exemplary embodiment of the present invention, the initial operation period signal **int** is

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activated during 5 cycles of the clock signal **ICLK**, it is to be noted that the activation period of the initial operation period signal **int** may vary by increasing or decreasing the number of flip-flops depending upon circumstances and conditions.

Referring to FIG. **3**, the coarse delay line **210** includes n number of unit delay sections **211** $\langle 1:n \rangle$ which are connected in series.

The respective unit delay sections **211** $\langle 1:n \rangle$ include a plurality of NAND gates **ND2** $\langle 1:n \rangle$, **ND3** $\langle 1:n \rangle$ and **ND4** $\langle 1:n \rangle$. The NAND gate **ND2** $\langle 1 \rangle$ of the unit delay section **211** $\langle 1 \rangle$ arranged at the front end of the coarse delay line **210** receives the initial operation period signal **int** and the feedback signal **FEDCLK**. The NAND gates **ND2** $\langle 2:n-1 \rangle$ of the second to $n-1^{st}$ unit delay sections **211** $\langle 2:n-1 \rangle$ respectively receive the output signals of the previous unit delay sections **211** $\langle 1:n-2 \rangle$ and external supply power **VDD**. The NAND gate **ND2** $\langle n \rangle$ of the unit delay section **211** $\langle n \rangle$ arranged at the back end of the coarse delay line **210** receives the initial operation period signal **intb** and the output signal of another unit delay section **211** $\langle n-1 \rangle$.

Each of n number of NAND gates **ND3** $\langle 1:n \rangle$ arranged in the respective unit delay sections **211** $\langle 1:n \rangle$ receives one corresponding bit of the first delay control signals **dlycnt** $\langle 1:n \rangle$ and the clock signal **ICLK**. n number of NAND gates **ND4** $\langle 1:n \rangle$ receive the output signals of the NAND gates **ND2** $\langle 1:n \rangle$ and the output signals of the NAND gates **ND3** $\langle 1:n \rangle$, and output the plurality of unit delayed signals **udly** $\langle 1:n-1 \rangle$ and the first pre-delayed signal **OUT1_PRE**.

In the coarse delay line **210** configured in this way, the first delay control signals **dlycnt** $\langle 1:n \rangle$, at the activation timing of the initial operation period signal **int**, have specified values (for example, 0, 0, . . . , 1). The feedback signal **FEDCLK** is inputted to the NAND gate **ND2** $\langle 1 \rangle$ of the first unit delay section **211** $\langle 1 \rangle$, is then delayed while passing through $n-1$ number of unit delay sections **211** $\langle 1:n-1 \rangle$, and is outputted as $n-1$ number of unit delayed signals **udly** $\langle 1:n-1 \rangle$. Since the output signal of the NAND gate **ND2** $\langle n \rangle$ of the n^{th} unit delay section **211** $\langle n \rangle$ has a high level, the clock signal **ICLK** is delayed by the delay time of the NAND gate **ND3** $\langle n \rangle$ of the n^{th} unit delay section **211** $\langle n \rangle$ and is outputted as the first pre-delayed signal **OUT1_PRE**.

Referring to FIG. **4**, the initial delay monitoring circuit **600** includes an initial phase information extraction unit **610**, a coarse initial delay information generation unit **620**, a unit delay **UDC**, a fine mixer **630**, and a fine initial delay information generation unit **640**.

The initial delay monitoring circuit **600** samples the $n-1$ -bit unit delayed signals **udly** $\langle 1:n-1 \rangle$ using a sampling signal and generates the first coarse initial delay information **S1** and the second coarse initial delay information **S2**. Also, the initial delay monitoring circuit **600** finely delays the sampling signal in the same manner as in the fine mixer **260** with the delay time of the coarse delay line **210** locked, detect a change of the first coarse initial delay information **S1**, and generates the fine initial delay information **S3**. The clock signal **ICLK** may be used as the sampling signal.

The initial phase information extraction unit **610** is configured to compare the phases of the clock signal **ICLK** and the $n-1$ -bit unit delayed signals **udly** $\langle 1:n-1 \rangle$ and generate initial phase signals **iniph** $\langle 1:n-1 \rangle$.

The initial phase information extraction unit **610** includes $n-1$ number of flip-flops **FF6** $\langle 1:n-1 \rangle$ which are connected in series. The respective flip-flops **FF6** $\langle 1:n-1 \rangle$ perform a function of latching respective bits of the $n-1$ number of unit delayed signals **udly** $\langle 1:n-1 \rangle$ in response to the clock signal **ICLK**, and output the initial phase signals **iniph** $\langle 1:n-1 \rangle$.

By the initial phase information extraction unit **610**, the initial phase information of the feedback signal FEDCLK and the clock signal ICLK is reflected on the logic values of the initial phase signals $\text{iniph}\langle 1:n-1 \rangle$.

The first coarse initial delay information **S1** and the second coarse initial delay information **S2** may be set to include only one signals having a logic value of '1' at different positions.

The coarse initial delay information generation unit **620** is configured to decode the initial phase signals $\text{iniph}\langle 1:n-1 \rangle$ and generate the first coarse initial delay information **S1** and the second coarse initial delay information **S2**.

The initial phase signal $\text{iniph}\langle 1 \rangle$ with an earliest timing among the initial phase signals $\text{iniph}\langle 1:n-1 \rangle$ may be provided to the switching unit **400** as the switching control signal SW.

Also, the coarse initial delay information generation unit **620** is configured to detect the phase differences of the clock signal ICLK and the plurality of unit delayed signals $\text{udly}\langle 1:n-1 \rangle$, and generate the first coarse initial delay information **S1**.

The coarse initial delay information generation unit **620** is configured to detect the phase differences of the clock signal ICLK and the plurality of unit delayed signals $\text{udly}\langle 1:n-1 \rangle$ and a low pulse width TLOW of the clock signal ICLK and generate the second coarse initial delay information **S2**.

The first coarse initial delay information **S1** is information which causes a delay time TDLL corresponding to the phase difference between the clock signal ICLK and the feedback signal FEDCLK to be set in the coarse delay line **210**.

The second coarse initial delay information **S2** is information which causes a delay time $\text{TDLL} + \text{TLOW}$ corresponding to the summation of the delay time TDLL and the low pulse width TLOW of the clock signal ICLK to be set in the coarse delay line **310**.

The fine mixer **630** is configured to mix the clock signal ICLK and the output signal of the unit delay UDC at a mixing ratio varying in response to preliminary fine initial delay information **S3_PRE** and output a resultant signal.

The fine mixer **630** may vary the delay time of the clock signal ICLK by varying the mixing ratio of the clock signal ICLK and the output signal of the unit delay UDC.

Also, the fine mixer **630** may be designed in the same manner as the fine mixer **260**. The unit delay time of the fine mixer **630** is set to be shorter than the unit delay time of the coarse delay line **210**.

The fine initial delay information generation unit **640** is configured to generate the fine initial delay information **S3** and the preliminary fine initial delay information **S3_PRE** in response to the initial operation period signals int and int2 and the first coarse initial delay information **S1**.

Here, the fine initial delay information **S3** is information for setting the initial delay times of the fine mixers **260** and **360**.

Referring to FIG. 5, the fine initial delay information generation unit **640** includes a latch **641**, a comparator **642**, a shift register **643**, and a multiplexer **644**.

The latch **641** is configured to latch the first coarse initial delay information **S1** in response to the initial operation period signal int .

The latch **641** latches the first coarse initial delay information **S1** in response to the falling edge of the initial operation period signal int .

The initial operation period signal int is, according to an example, a signal which represents the completion of operations for generating the first coarse initial delay information **S1** and the second coarse initial delay information **S2**, that is, a signal which notifies that control of the first coarse initial

delay information **S1** and the second coarse initial delay information **S2** is completed. The falling edge of the initial operation period signal int may represent the completion of adjustments of the first coarse initial delay information **S1** and the second coarse initial delay information **S2**, that is, a completion of coarse locking.

The comparator **642** is configured to compare the latched first coarse initial delay information **S1** and the first coarse initial delay information **S1**, and generate a comparison signal dcmp .

The shift register **643** is configured to change the preliminary fine initial delay information **S3_PRE** in response to the initial operation period signal int2 and the comparison signal dcmp .

The shift register **643** changes the preliminary fine initial delay information **S3_PRE** in the case where the comparison signal dcmp is logic low during the activation period (for example, the logic high period) of the initial operation period signal int2 .

Also, the shift register **643** maintains the value of the preliminary fine initial delay information **S3_PRE** in a current state in the case where the comparison signal dcmp is logic high.

If the initial operation period signal int2 is deactivated, that is, becomes logic low, the shift register **643** maintains the preliminary fine initial delay information **S3_PRE**, regardless of the comparison signal dcmp .

The multiplexer **644** is configured to selectively output the preliminary fine initial delay information **S3_PRE** or a logic low level, as the fine initial delay information **S3**, in response to the comparison signal dcmp .

The multiplexer **644** outputs a signal of which each bit is logic low as the fine initial delay information **S3** if fine locking is not completed, that is, the comparison signal dcmp is logic low.

Also, the multiplexer **644** outputs the preliminary fine initial delay information **S3_PRE** as the fine initial delay information **S3** if fine locking is completed, that is, the comparison signal dcmp is logic high.

In an initial operation, since fine locking is not completed, the comparison signal dcmp of a logic low level is outputted, and accordingly, the multiplexer **644** outputs the signal of which each bit is logic low, as the fine initial delay information **S3**.

Therefore, the fine mixer **260** bypasses and outputs the first pre-delayed signal OUT1_PRE as the first delayed signal OUT1 .

As described above, in the state in which the delay time of the coarse delay line **210** is locked, as the fine mixer **630** gradually adjusts the delay time of the clock signal ICLK, the value of the first coarse initial delay information **S1** changes at a certain timing.

However, the value of the latched first coarse initial delay information **S1** is retained regardless of the operation of the fine mixer **630**.

Changing of the value of the first coarse initial delay information **S1** means that the phase difference between the clock signal ICLK and the feedback signal FEDCLK decreases below the unit delay time of the fine mixer **630**, i.e., fine locking of the clock signal ICLK and the feedback signal FEDCLK is completed.

Thus, if the value of the first coarse initial delay information **S1** changes and becomes different from the value of the latched first coarse initial delay information **S1**, the comparator **642** transitions the comparison signal dcmp to a logic level different from a previous logic level (for example, to a logic high level).

Since fine locking is completed, that is, the comparison signal *dcmp* is logic high, the multiplexer **644** outputs the fine-locked preliminary fine initial delay information *S3_PRE* as the fine initial delay information *S3*.

Referring to FIG. 6, the shift register **250** includes a counter **251** configured to perform a counting operation in response to the phase comparison signal *dcmp* and output count signals *count<1:m>* of *m* bits, a decoder **252** configured to decode the count signals *count<1:m>* of *m* bits and output decoding signals *phdec<1:n>*, a multiplexer **253** configured to selectively output the decoding signals *phdec<1:n>* or the first coarse initial delay information *S1* in response to the initial operation period signal *int*, and a latch **254** configured to latch the output signal of the multiplexer **253** and output the first delay control signals *dlycnt<1:n>*.

The counter **251** increases or decreases the logic values of the count signals *count<1:m>* of *m* bits according to the phase comparison signal *phcmp*. Here, it may be understood that the counter **251** increases or decreases the logic values of the count signals *count<1:m>* according to the phase information of the clock signal *ICLK* and the feedback signal *FEDCLK*. Thereafter, the decoder **252** decodes the count signals *count<1:m>* of *m* bits and outputs the decoding signals *phdec<1:n>*. The decoding signals *phdec<1:n>* may have a value in such a type that only one bit of them has the logic value of '1'. The decoding signals *phdec<1:n>* may be realized in such a manner that the logic value of '1' is moved by one cipher as the logic values of the count signals *count<1:m>* of *m* bits change.

If the initial operation period signal *int* is activated, the multiplexer **253** blocks the decoding signals *phdec<1:n>* and passes the first coarse initial delay information *S1*. At this time, the logic values of the first delay control signals *dlycnt<1:n>* are set to specified values (for example, 0, 0, . . . , 1) in the latch **254**. Thereafter, when the first coarse initial delay information *S1* is inputted to the latch **254**, the latch **254** latches the first coarse initial delay information *S1* and thereby outputs the first delay control signals *dlycnt<1:n>*. In other words, during the initial operation period according to the initial operation period signal *int*, the first coarse initial delay information *S1* is outputted as the first delay control signals *dlycnt<1:n>*. The coarse delay line **210** applies a delay time for minimizing the phase difference between the clock signal *ICLK* and the feedback signal *FEDCLK*, to the clock signal *ICLK* in response to the first coarse initial delay information *S1*.

Then, if the initial operation period signal *int* is deactivated, the multiplexer **253** blocks the first coarse initial delay information *S1* and passes the decoding signals *phdec<1:n>*. Thereafter, the latch **254** latches the decoding signals *phdec<1:n>* and thereby outputs the first delay control signals *dlycnt<1:n>*. At this time, since the phase difference between the clock signal *ICLK* and the feedback signal *FEDCLK* is not so substantial, the logic values of the decoding signals *phdec<1:n>* will approximate to the logic values of the first coarse initial delay information *S1*. Accordingly, even though the logic values of the first delay control signals *dlycnt<1:n>* and the decoding signals *phdec<1:n>* vary in response to the phase comparison signal *phcmp*, time taken until the logic values of the first delay control signals *dlycnt<1:n>* are locked may decrease.

The coarse delay line **310** of the second loop circuit **300** may be configured as shown in FIG. 7 in such a manner that the NAND gate *ND2<1>* is removed from the configuration of the coarse delay line **210** shown in FIG. 3, and the external

supply power *VDD* is inputted to a NAND gate *ND4<1>* and is inputted to a NAND gate *ND2<n>* instead of the initial operation period signal *intb*.

Referring to FIG. 8, the shift register **350** of the second loop circuit **300** may be configured in the same way as the shift register **250** shown in FIG. 6 except that the second coarse initial delay information *S2* is inputted to the multiplexer **253**.

Operations of the synchronization circuit **100** in accordance with an embodiment of the present invention, configured as mentioned above, will be described below with reference to FIGS. 9*a* and 9*b*.

In an embodiment of the present invention, the switching unit **400** is configured to enable a half cycle (half *tCK*) operation.

Namely, in the case where the delay time *TDLL* corresponding to the phase difference between the clock signal *ICLK* and the feedback signal *FEDCLK* is longer than the half cycle of the clock signal *ICLK*, the clock bar signal *ICLKB* is inputted to the first loop circuit **200** as the first input signal *IN1*, and the clock signal *ICLK* is inputted to the second loop circuit **300** as the second input signal *IN2*.

Accordingly, the first loop circuit **200** may operate using two signals, that is, the clock bar signal *ICLKB* and the feedback signal *FEDCLK*, which have a phase difference no longer than the half cycle of the clock signal *ICLK*.

Of course, in the case where the delay time *TDLL* corresponding to the phase difference between the clock signal *ICLK* and the feedback signal *FEDCLK* is no longer than the half cycle of the clock signal *ICLK*, the clock signal *ICLK* is inputted to the first loop circuit **200** as the first input signal *IN1*, and the clock bar signal *ICLKB* is inputted to the second loop circuit **300** as the second input signal *IN2*.

Further, as a signal for determining whether or not the delay time *TDLL* is longer than the half cycle of the clock signal *ICLK* and for controlling the switching unit **400**, the switching control signal *SW*, that is, the initial phase signal *iniph<1>* may be used.

In the case where the phase difference between the clock signal *ICLK* and the feedback signal *FEDCLK* is no longer than the half cycle of the clock signal *ICLK*, the initial phase signal *iniph<1>* is outputted at a high level. That is to say, the switching control signal *SW* becomes logic high.

In the case where the phase difference between the clock signal *ICLK* and the feedback signal *FEDCLK* is longer than the half cycle of the clock signal *ICLK*, the initial phase signal *iniph<1>* is outputted at a low level. That is to say, the switching control signal *SW* becomes logic low.

The initial delay monitoring circuit **600** shown in FIG. 4 generates the first coarse initial delay information *S1*, the second coarse initial delay information *S2* and the fine initial delay information *S3* according to the switching control signal *SW* which determines whether or not the delay time *TDLL* corresponding to the phase difference between the clock signal *ICLK* and the feedback signal *FEDCLK* is longer than the half cycle of the clock signal *ICLK*.

Referring to FIG. 9*a*, in the case where the phase difference between the clock signal *ICLK* and the feedback signal *FEDCLK* is no longer than the half cycle of the clock signal *ICLK*, the initial phase signals *iniph<1:n-1>* become a type of '1, 1, . . . , 0, 0, . . . , 1, 1, . . .'. Since the initial phase signal *iniph<1>* has a high level, the switching control signal *SW* of a logic high level is outputted.

The number of bits consecutively having the value of '1' among the initial phase signals *iniph<1:n-1>* may represent the delay time *TDLL* corresponding to the phase difference between the clock signal *ICLK* and the feedback signal *FEDCLK*. Accordingly, the coarse initial delay information gen-

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eration unit **620** shown in FIG. **4** generates the first coarse initial delay information **S1** which has logic values for setting the delay time of the coarse delay line **210** to the delay time TDLL, using the bits consecutively having the value of '1' among the initial phase signals $iniph<1:n-1>$.

Also, the number of bits consecutively having the value of '0' among the initial phase signals $iniph<1:n-1>$ may represent the low pulse width TLOW of the clock signal ICLK. At this time, duty cycle correction is implemented by mixing the clock bar signal ICLKB delayed by the low pulse width TLOW of the clock signal ICLK and the clock signal ICLK. Hence, the coarse initial delay information generation unit **620** shown in FIG. **4** generates the second coarse initial delay information **S2** which has logic values for setting the delay time of the coarse delay line **310** to the delay time TDLL+TLOW, using the bits consecutively having the value of '0' among the initial phase signals $iniph<1:n-1>$.

The fine initial delay information generation unit **640** shown in FIG. **4** generates the fine initial delay information **S3**.

Accordingly, the clock signal ICLK is inputted to the first loop circuit **200** as the first input signal **IN1**, and the clock bar signal ICLKB is inputted to the second loop circuit **300** as the second input signal **IN2**.

The initial delay time of the coarse delay line **210** of the first loop circuit **200** is set according to the first coarse initial delay information **S1**, the initial delay time of the coarse delay line **310** of the second loop circuit **300** is set according to the second coarse initial delay information **S2**, and the initial delay times of the fine mixers **260** and **360** are set according to the fine initial delay information **S3**.

The first pre-delayed signal **OUT1_PRE** is a signal which is acquired by actually delaying the clock signal ICLK by TDLL, and the second pre-delayed signal **OUT2_PRE** is a signal which is acquired by actually delaying the clock bar signal ICLKB by TDLL+TLOW.

As described above, duty cycle correction is implemented by mixing the clock bar signal ICLKB delayed by the low pulse width TLOW of the clock signal ICLK and the clock signal ICLK.

Thus, as the duty cycle compensation unit **500** mixes the first delayed signal **OUT1** and the second delayed signal **OUT2** at a mixing ratio of 1:1, the delay-locked and duty cycle-compensated output signal **DOUT** is generated.

Referring to FIG. **9b**, in the case where the phase difference between the clock signal ICLK and the feedback signal FEDCLK is longer than the half cycle of the clock signal ICLK, the initial phase signals $iniph<1:n-1>$ become a type of '0, 0, . . . , 1, 1, . . . , 0, 0, . . .'. Since the initial phase signal $iniph<1>$ has a low level, the switching control signal **SW** of a logic low level is outputted.

Since the switching control signal **SW** is logic low, after the first coarse initial delay information **S1**, the second coarse initial delay information **S2** and the fine initial delay information **S3** are set, the clock bar signal ICLKB is inputted to the first loop circuit **200** as the first input signal **IN1**, and the clock signal ICLK is inputted to the second loop circuit **300** as the second input signal **IN2**.

In other words, the clock bar signal ICLKB is controlled according to the first coarse initial delay information **S1**.

Therefore, as shown in FIG. **9b**, in the case where the switching control signal **SW** is logic low, TLOW and TDLL of the feedback signal FEDCLK to be actually acquired respectively correspond to THIGH and TDLL'-THIGH of the feedback signal FEDCLK in the case where the switching control signal **SW** is logic high.

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The number of bits consecutively having the value of '0' among the initial phase signals $iniph<1:n-1>$ may represent the delay time TDLL corresponding to the phase difference between the clock signal ICLK and the feedback signal FEDCLK. Accordingly, the coarse initial delay information generation unit **620** shown in FIG. **4** generates the first coarse initial delay information **S1** which has logic values for setting the delay time of the coarse delay line **210** to the delay time TDLL, using the bits consecutively having the value of '0' among the initial phase signals $iniph<1:n-1>$.

The number of bits consecutively having the value of '1' among the initial phase signals $iniph<1:n-1>$ may represent the low pulse width TLOW of the clock signal ICLK. Here, duty cycle correction is implemented by mixing the clock bar signal ICLKB delayed by the low pulse width TLOW of the clock signal ICLK and the clock signal ICLK. Hence, the coarse initial delay information generation unit **620** shown in FIG. **4** generates the second coarse initial delay information **S2** which has logic values for setting the delay time of the coarse delay line **310** to the delay time TDLL+TLOW, using the bits consecutively having the value of '1' among the initial phase signals $iniph<1:n-1>$.

The fine initial delay information generation unit **640** shown in FIG. **4** generates the fine initial delay information **S3**.

After the first coarse initial delay information **S1**, the second coarse initial delay information **S2** and the fine initial delay information **S3** are generated in these ways, the clock bar signal ICLKB is inputted to the first loop circuit **200** as the first input signal **IN1**, and the clock signal ICLK is inputted to the second loop circuit **300** as the second input signal **IN2**, according to the switching control signal **SW** of logic low.

In the case where the initial operation period signal **int** is deactivated, the shift registers **250** and **350** do not receive the first coarse initial delay information **S1** and the second coarse initial delay information **S2**, and control the operations of the coarse delay lines **210** and **310** while changing the logic values of the first delay control signals $dlycnt<1:n>$ in response to the respective phase comparison signals **phcmp** and **phcmp2**.

The coarse delay line **210** does not receive the feedback signal FEDCLK and performs an operation of delaying the clock signal ICLK under the control of the first delay control signals $dlycnt<1:n>$.

The first delayed signal **OUT1** and the second delayed signal **OUT2** are generated by the operations of the first loop circuit **200** and the second loop circuit **300**, and the delay-locked and duty cycle-compensated output signal **DOUT** is generated by the duty cycle compensation unit **500**.

As is apparent from the above descriptions, by the synchronization circuit according to an embodiment of the present invention, times required for a delay locking operation and a duty cycle compensating operation can be shortened.

While certain embodiments have been described above, it will be understood to those skilled in the art that the embodiments described are by way of example only. Accordingly, the synchronization circuit described herein should not be limited based on the described embodiments. Rather, the synchronization circuit described herein should only be limited in light of the claims that follow when taken in conjunction with the above description and accompanying drawings.

What is claimed is:

1. A synchronization circuit comprising:
 - a first delay unit configured to delay an input signal by a delay time corresponding to first initial delay information and generate a pre-delayed signal;

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a second delay unit configured to delay the pre-delayed signal by a delay time corresponding to second initial delay information and generate a delayed signal; and an initial delay monitoring circuit configured to generate the first initial delay information and the second initial delay information in response to internal delayed signals of the first delay unit and the input signal.

2. The synchronization circuit according to claim 1, wherein a unit delay time of the second delay unit is set to be shorter than a unit delay time of the first delay unit.

3. The synchronization circuit according to claim 1, further comprising:

- a shift register configured to set the delay time of the first delay unit in response to the first initial delay information.

4. The synchronization circuit according to claim 1, further comprising:

- an initial operation setting unit configured to generate initial operation period signals in response to the input signal and an operation start signal.

5. The synchronization circuit according to claim 1, further comprising:

- a replica delay configured to delay the delayed signal by a preset time and generate a feedback signal.

6. The synchronization circuit according to claim 5, wherein the first delay unit is configured to delay the feedback signal and generate the internal delayed signals.

7. The synchronization circuit according to claim 1, wherein the initial delay monitoring circuit is configured to detect phase differences between the input signal and the internal delayed signals and generate the first initial delay information.

8. The synchronization circuit according to claim 1, wherein the initial delay monitoring circuit is configured to delay the input signal with the delay time of the first delay unit locked, detect a corresponding change in the first initial delay information, and generate the second initial delay information.

9. The synchronization circuit according to claim 1, wherein the initial delay monitoring circuit comprises:

- a fine mixer configured to delay by a predetermined delay time and output the input signal in response to preliminary initial delay information;
- a first initial delay information generation unit configured to decode phase differences between an output signal of the fine mixer and the internal delayed signals and generate the first initial delay information; and
- a second initial delay information generation unit configured to detect a change in the first initial delay information according to a change of the preliminary initial delay information, and output the preliminary initial delay information at a time when the change in the first initial delay information is detected, as the second initial delay information.

10. The synchronization circuit according to claim 9, wherein the fine mixer is configured in the same manner as the second delay unit.

11. The synchronization circuit according to claim 9, wherein the second initial delay information generation unit comprises:

- a latch configured to latch the first initial delay information of which the change is completed;
- a comparator configured to compare first initial delay information latched by the latch and the first initial delay information and generate a comparison signal;

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- a shift register configured to change the preliminary initial delay information in response to the comparison signal; and
- a multiplexer configured to output the preliminary initial delay information as the second initial delay information in response to the comparison signal.

12. The synchronization circuit according to claim 1, wherein the initial delay monitoring circuit is configured to output the second initial delay information with a preset value to the second delay unit until generation of the second initial delay information is completed.

13. A synchronization circuit comprising:

- a first loop circuit configured to adjust a delay time of a first input signal in response to first coarse initial delay information and fine initial delay information, and generate a first delayed signal;
- a second loop circuit configured to adjust a delay time of a second input signal by a preset initial delay time in response to second coarse initial delay information and the fine initial delay information, and generate a second delayed signal;
- a duty cycle compensation unit configured to compensate for a duty cycle of the first delayed signal using the second delayed signal; and
- an initial delay monitoring circuit configured to generate the first coarse initial delay information, the second coarse initial delay information and the fine initial delay information in response to internal delayed signals of the first loop circuit and the first input signal.

14. The synchronization circuit according to claim 13, further comprising:

- an initial operation setting unit configured to generate a first initial operation period signal and a second initial operation period signal in response to the first input signal and an operation start signal.

15. The synchronization circuit according to claim 14, wherein the first loop circuit comprises:

- a first delay unit configured to delay the first input signal and generate a first pre-delayed signal;
- a second delay unit configured to delay the first pre-delayed signal by a delay time in response to the fine initial delay information and generate a first delayed signal;
- a replica delay configured to delay the first delayed signal by a preset time and generate a feedback signal; and
- a shift register configured to set a delay time of the first delay unit in response to the first initial operation period signal and the first coarse initial delay information.

16. The synchronization circuit according to claim 14, wherein the second loop circuit comprises:

- a first delay unit configured to delay the second input signal and generate a second pre-delayed signal;
- a second delay unit configured to delay the second pre-delayed signal by a delay time in response to the fine initial delay information and generate a second delayed signal; and
- a shift register configured to set a delay time of the first delay unit in response to the first initial operation period signal and the second coarse initial delay information.

17. The synchronization circuit according to claim 13, wherein the duty cycle compensation unit comprises a mixer configured to mix the first delayed signal and the second delayed signal.

18. The synchronization circuit according to claim 13, wherein the initial delay monitoring circuit is configured to detect phase differences between the first input signal and the internal delayed signals and generate the first coarse initial delay information, and detect phase differences between the

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first input signal and the internal delayed signals and a row pulse width of the first input signal and generate the second coarse initial delay information.

19. The synchronization circuit according to claim 13, wherein the initial delay monitoring circuit is configured to detect a change in the first coarse initial delay information with the delay time of the first loop circuit locked and generate the fine initial delay information.

20. The synchronization circuit according to claim 13, wherein the initial delay monitoring circuit comprises:

a fine mixer configured to delay by a predetermined delay time and output the first input signal in response to preliminary initial delay information;

a coarse initial delay information generation unit configured to decode phase difference information between an output signal of the fine mixer and the internal delayed signals and generate the first coarse initial delay information and the second coarse initial delay information; and

a fine initial delay information generation unit configured to detect a change in the first coarse initial delay information according to a change of the preliminary initial delay information, and output the preliminary initial delay information at a time when the change in the first coarse initial delay information is detected, as the fine initial delay information.

21. The synchronization circuit according to claim 20, wherein the initial delay monitoring circuit further comprises:

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an initial phase information extraction unit configured to compare phases of the output signal of the fine mixer and the internal delayed signals and generate the phase difference information, and output one bit of signal bits of the phase difference information as a switching control signal.

22. The synchronization circuit according to claim 20, wherein the fine initial delay information generation unit comprises:

a latch configured to latch the first coarse initial delay information of which the change is completed;

a comparator configured to compare first coarse initial delay information latched by the latch and the first coarse initial delay information and generate a comparison signal;

a shift register configured to change the preliminary initial delay information in response to the comparison signal; and

a multiplexer configured to output the preliminary initial delay information as the fine initial delay information in response to the comparison signal.

23. The synchronization circuit according to claim 21, further comprising:

a switching unit configured to output a clock signal or a clock bar signal as the first input signal or the second input signal in response to the switching control signal.

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